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A Study on the Nutritional Value of Three Plant Species Alhagi (Alhagi persarum), Psyllium (Plantago psyllium), and Artemisia (Artemisia Biennis Wild)

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Abstract- This research has been conducted following the aim of studying the nutritional value of three dominant plant species in Sistan region including Alhagi (Alhagi persarum), Psyllium (Plantago psyllium), and Artemisia (Artemisia Biennis Wild) and the sampling has been done at the vegetative stage. These samples, then, were milled under dry shade conditions and the chemical components of the samples which include: dry matter, organic matter, ash, crud protein, crud fat, cell wall, and ADF were measured in the laboratory. These samples, then, were milled under dry shade conditions and the chemical components of the samples which include: dry matter, organic matter, ash, crud protein, crud fat, cell wall, and ADF were measured in the laboratory. Organic Matter Digestibility (OMD) and Metabolizable Energy (ME) were calculated using the gas production method. The results showed that between these samples, in terms of their chemical components, there is a significant difference ($P<0.05$). The highest amounts of crud protein and ADF were that of the Artemisia (11.46) and Psyllium (39.98) respectively. The results concluded from the produced amounts of gas (mg) at different incubation hours indicated that the highest and lowest amounts of produced gas were that of Artemisia (67.19) and Psyllium (55.34) respectively. Low cp might be the cause of Psyllium having the lowest amounts of both OMD and ME. Regarding the degradability and effective degradability parameters at different incubation hours, a significant difference was observed ($P<0.05$).

Keywords- *Forage plants, Gas production, Dry matter degradability, Sistan*

I. INTRODUCTION

Most of the Iran is dry land and usually it is made of saline soil. Only halophilic plants can grow in such conditions. Sistan Region's vegetation mainly consists of halophilic plants (Sobh Khiz et al, 2006). Except a few cultivated species, the rest are halophilic and common plants of the region which grow at autumn (Bashtini et al, 2005). These plants, in dry lands, are important and used as fuel, medicine, animal feed, air and soil-carbon fixation (Tavakoli et al, 1999). These plants grow in clay, sandy mounds in the beaches, and saline soil but they are, especially during periods of drought, the main food source for grazing cattle (Asadi et al, 2001). According to Ayoub & Malcom (1993), the chemical components and nutritional value of dry land forage is very different and these differences are not only because of having different species there, but because of regional differences. Bashtini and Tavakoli (2002) studied the nutritional value of five dominant halophilic plant species in deserts of Khorasan and reported that the amount of crud protein to be from 6 to 11.6 percent and the amount of crud fiber to be from 8.5 to 20.4 percent. The observed difference and change in chemical components and nutritional value of plants is under the influence of plant species which is determined by regional conditions. Determining the nutritional value of plants in every region is different because there exists a different climate which asks for different species. The present research, therefore, was conducted to study the nutritional value of six dominant plants in dry lands of Sistan using in vitro laboratory methods and in situ techniques.

II. MATERIALS AND METHODOLOGY

A. Sampling Area

According to local weather stations, the average amount of yearly precipitation in the area is 61 ml and the average temperature is about 21˚c. Based on climate classification categories, the region is warm and dry. The soil, because of high amounts of minerals, is considered to be saline or alkaline soil and thus the vegetation is mainly made of the plants accustomed to such soil. These plants are the main food source for the local cattle especially small ruminants (Sobh Khiz, 2006).

Sampling of Alhagi (Alhagi persarum), Psyllium (Plantago psyllium), and Artemisia (Artemisia Biennis Wild) was done in the latter days of the vegetative stage (May) from five specified locations. In each location, three samples from three different places were collected, each about 500 g using the random-systematic method. After getting dried outdoors for 72 h, the samples were milled with a miller having a sieve with 2 mm pores.

B. Determination of the Chemical Components

The chemical components of experimental groups [including organic matter (OM), crud protein (CP), ether essence (EE), and ash] were measured by the proposed standard method AOAC (1990). The neutral detergent fiber (NDF) and acid detergent fiber (ADF) were measured by the method of Van Soest et al (1991). And to measure the water soluble carbohydrates (WSC), the phenol-sulfuric method by Bois et al (1993) was used.

C. Determination of the Degradability of Nutrients

Dry matter degradability was done using three male and mature sheep (castrated and fistulated) having an average weight of 35±2.5 kg and the fistula was in their rumen. The sheep's ration was determined at the maintenance level calculated according to NRC 2000 tables using regular food (dry alfalfa, hay, barley, bran, and cotton seed meal) and the adaptation period was two weeks. The sheep were fed two times a day at 6 and 18 o'clock and water was always available for them. An amount of 5 grams of milled and dry sample was put in Dacron bags made of poly ester fibers by the size 15*8 cm having 50 µm pores (Orskov et al, 1980). The bags were put in the sheep's rumen for 3, 6, 12, 24, 48, 72, and 96 h and after that each indicated hour passed, they were taken out, washed, and dried in the Avon at 65˚c for 48 hours. The degraded amounts were measured by calculating the difference between the primary sample and the residue in the bag. Degradability parameters (soluble part, insoluble part, and degradation rate constant) was studied according to the exponential equation [$P=a+b(1-e^{-ct})$] (Orskov et al, 1980). In this equation, *P* is the degradability percentage at times indicated by *t*, *a* is the intercept at the time 0 and the indicator of soluble matters, *b* is the slow fraction of degradation, *(a+b)* is the fraction that is potentially degradable, and *c* is the degradation rate (percentage per hour). The effective degradability of rumen (ED) was calculated according to ED=a+[b×c/c+k]. In this formula, *k* is the speed by which the food passes through rumen; here, it is decided to be 0.02.

D. Gas Production Test

Determination of laboratory fermentation and the amount of gas production was done using the method by Menke and Steingass (1988). To do this, rumen emulsion of the three male and mature sheep was obtained. And an amount of 210±5 mg sample (3 repetitions) was poured into every syringe and 30 ml of buffered and limpid rumen liquid was added to it and they were put in the incubator at 39˚c. The amount of gas production at hours 2, 4, 8, 12, 16, 24, 48, 72, and 96 was measured and recorded. The data on cumulative gas production was analyzed using this equation: $Y=b(1-e^{-ct})$ in which *b* is the gas production from insoluble and non-fermenting fraction (ml in 200 mg dry matter), *c* is the constant gas production ratio for fraction b (h^{-1}), *t* is the incubation time, and *Y* is the produced gas in t (Getchu et al, 2004). To estimate the organic matter digestibility (OMD) and the metabolizable energy (ME), the Menke and Steingass (1988) pattern was used as follows:

OMD = 14/88+ 0/8893 GP +0/448 CP+ 0/0651XA

ME= 2/2 +0/1357 GP +0/057 CP + 002859 CP^2

OMD is the organic matter digestibility (percentage), *GP* is the gas production volume corrected for 24 h (ml in 200 mg dry matter), *CP* is the crud protein (dry matter percentage), *XA* is the crud ash (dry matter percentage), *ME* is the metabolizable energy (MJ in dry matter kg).

III. Calculations and Statistical Analysis

The acquired data for chemical components, degradability of dry matter, and gas test parameters went through statistical analysis in a random pattern. The data were first tested with Minitab version to make sure they are normal and then, using the SAS (2002) statistical software, they were statistically analyzed using the GLM method. Next, the averages were compared using the Duncan's multiple range test assuming an error of less than 0.05. The results of in situ test and gas production were analyzed using the software Neway and Fitcurve respectively.

IV. Results and Discussion

A. Chemical Components

Table 1 shows the chemical components of the studied plants. According to the results inferred from the chemical components of these plants, the amount of crud protein in Alhagi, Psyllium, and Artemisia was calculated to be 11.07, 5.47, and 11.46 percent respectively. Usually, the existence of an amount of 7.5% crud protein is considered to be the quality threshold for forage. The proposed range is for goats (NRC, 2000). Also, Butterworth (1985) mentions that the least amount of crud protein for maintaining the digestion process in ruminants is 7 percent. In a research done by Arzani et al (2007) on Artemisia in Markazi Province, the amount of crud protein was calculated to be 12.40% which is close the results of this study. According to Hosseini Nejad Sarbanani (2009), the least amounts of crud protein in forage belongs to Salsola (5.93%) and the highest amount is that of the Chenopodium (14.73%) and these results are close to that of the findings in this region. There is a significant relationship between the amounts of crud protein and other factors that affect forage quality (Erfan Zade, 2009). The least amount of dry matter was that of the plant Alhagi (87.64). Bashtini and Tavakoli (2002), in their study, reported the amounts of dry matter in five halophilic plants to be between 86.3 to 93.4% which is in agreement with findings of the present study. The highest amount of crud ash was that of the Psyllium (11.31). Takasi et al (2007), in their study (on Haloxylon. Sp), have reported the amount of crud ash to be 14.1% and then contribute it to the halophilic nature of the plant which makes it absorb more minerals. Also, Tohidi (2007) has reported the amount of ash for Alhagi and Artemisia in Yazd Province to be 7.5 and 5.5 percent. The observed difference for the amount of crud ash between this study and others could be contributed to the sampling stage, rangeland species, soil type of rangelands, climate, and the weather condition in this region (Varmqani, 2007; Dubbs et al, 2003; Khanum et al, 2007). High amounts of ash in Sistan show that the plants being halophilic and the existing minerals affect the absorption and high amounts of ash (Peyravi, 2009).

The highest amount of crud fat is that of Alhagi (2.34%) and the lowest amount was that of Artemisia (2.07%). There was no significant difference ($P<0.05$) between the studied samples regarding the crud fat. Peyravi (2009) states that the amount of crud fat in the studied samples in Sistan ranges from 1.5 to 3.13 percent which is close to the findings of this research. The amount of cell wall in the studied samples ranges from 57.80 to 69.95 percent and the highest amount was that of the Alhagi. Hosseini Nejad Sarbanani (2009) reports that the amount of cell wall (NDF) for the studied samples ranges from 30.41 to 70.96 percent. The highest amount of NDF is that of the plant Bermuda grass (Cynodon dactylon) and the lowest amount of NDF was that of the plant Suaeda. The cell wall and crud fiber increase as the plant grows up. It is because that as the plant grows the need for supportive tissues increases and thus more and more amounts of structural carbohydrates would be produced. ADF showed a range of 54.19 to 39.98 percent. Malan and Rethman (2003), in their study on 16 types of Atriplex, have reported that factors like crude fat, chemical components, fiber amount, vegetative form, and growth stage affect the plant palatability. It could be noted that changes in nutrition quality of may be a result of increased amounts of fiber and lignin at harvest time which have lower nutrition value. As the plant grows up, it will need more and more supportive and solid tissues. These tissues are mainly built from cellulose and hemicellulose. As the plant ages, these structural carbohydrates increase while the protein amounts decrease; thus, there exists a reverse relationship between the amounts of protein and crud fibers (Arzani etal, 1998; Marinas et al, 2003).

B. Dry Matter Degradability

Table 2 shows the results of dry matter degradability parameters. Regarding parameter (a), the fast fraction of degradation, parameter (b), the slow fraction of degradation, (c) degradability rate constant, and (ED), effective degradation, there was no significant case ($P<0.05$) among the studied plants. The highest amount of degradability for fraction a (fast degradation) was that the plant Artemisia (23.263%) and the lowest amount was that of the plant Psyllium (8.510%) and this is probably a result of higher amounts of crud protein and crud ash of the Artemisia in comparison with the other two which is in agreement with the reports of Mahala et al (2007). They reported that, studying 6 kinds of forage plants, the plants with higher amounts of protein also had higher percentages of parameter a. Such state indicates the higher potential for degradability (Gomez et al, 1994). The highest percentage for the slow fraction of degradation was that of the plant Psyllium (58.72%) and the least was that of the plant Artemisia (47.05%). According to the study by Daalkhaijav et al (2000) on the desert steppe rangelands, the lowest amount of parameter b was that of the semi-bush plants fraction. The potential degradability, (a+b), of the studied plants ranged between 67.23 to 70.31 percent and the highest amount was that of the plant Artemisia ($P<0.05$). Riasi et al (2008) stated that the reason for the observed decrease in dry matter degradability rate of the feed is low amounts of ash and high amounts of cell wall which justifies the findings of this study. Also, the highest amounts of ED was that of the plant Artemisia (58.87) calculated by the flow rate of 0.02 ($P<0.05$). Ramirez et al (2009) have stated that the dry matter degradability in all of the studied plants ranges from 0.33 to 0.62 percent and they also showed that the amount of crud protein has a positive effect on food disappearance in rumen. Results of the present study indicated that parameter c had the highest amounts of degradability rate constant in Artemisia. Van Soest (1994), in a report on disappearance rate, stated that it depends on whether the microbes have enough time to adjoin with the cell wall and the nature of cell wall itself.

C. Gas Production

The average amounts of produced gas from different studied plants at different incubation hours showed significant differences ($p<0.05$) (table 3). The amount of produced gas in 96 incubation hours ranged from 54.72 to 63.78 ml and the plant Artemisia had the highest amount of produced gas ($p<0.05$). The amount of produced gas is usually affected by the chemical components of the plant. On the whole, as the incubation time increased, so did the produced gas which is in agreement with the findings of other studies (Mansuri et al, 2003). To justify this, it can be said that according to Laudadio et al (2009) in their study on the halophyte plants of south Tunisia, they concluded that there is a reverse relative relationship between the amounts of crud protein and structural carbohydrates in halophyte plants. Notron (2003) reported that the feed should contain at least 10% crud protein. Thus, the feed that has less than 10% protein may reduce microbe activity in rumen resulting in production of lower amounts of gas. Regarding Psyllium, not only the amount of crud protein (5.47) was lower than the required amount, but high amounts of ash and low amounts of organic matter too contributed to low fermentation and thus gas production. These results are in agreement with findings of Peyravi (2009) studying 9 rangeland species of Sistan Region.

Table 3 shows the gas production parameters of the studied plants which indicates that there is a significant difference between them ($P<0.05$). The highest observed amount for fraction b is that of the plant Artemisia (67.19 ml). Gas production rate (c) is related to the easily digestible carbohydrates which are readily available for microbes (Songsak, 2007). The reason for higher amounts of gas production of Artemisia is that it has more crud protein and water soluble carbohydrates than the other species.

D. Organic Matter Digestibility (OMD), and Metabolizable Energy (ME)

OMD and ME were studied based on the gas production system during laboratory fermentation for the studied species and the results showed a significant difference ($P<0.05$) (table 4). The OMD of the plants ranged from 54.94 to 61.97% and the highest rate was that of the plant Artemisia while the lowest rate was that of the plant Psyllium. OMD is one of the main indexes for determining the nutritional value of the forage which has a direct relationship with gas production volume and ash density. Paya et al (2007) have stated that OMD is the actual fraction of the organic matter in the food that gets digested. Lee et al (2000) estimated the OMD for rangeland plants to range from 50 to 77% and stated that the observed reduction of gas production in the rumen is the result of decreased dry matter digestibility and organic matter which is in agreement with the findings of this study. ME was estimated to range from 8.19 to 9.29 (MJ per kg dry matter) in the studied species and the least amount was that of the plant Psyllium ($P<0.05$). Low amounts of crud protein and high amounts of crud ash which result in having low amounts of organic matter, caused the Psyllium to have such low OMD in its dry matter while compared with the other studied species. This also affects ME in a negative way and reduces the estimated amount of ME in Psyllium compared to other studied species. Menke and Steingass (1998) have reported that there is a high correlation between ME, produced amounts of gas, and chemical components of the food. Also, Khanum et al (2007) have reported that the observed difference in ME for different foods is a result of different amounts of fermentable carbohydrates and available nitrogen. Furthermore, Larbi et al (1998) have reported on existence of a positive relationship between amounts of crud protein and gas production.

V. Conclusion and Overall Discussion

Results of the present study showed that dry matter ED, cell wall, and ADF differ in different rangeland species. Thus, when formulating diets for ruminants, degradability parameters must be noted. The data acquired from this study could be used to formulate diets for grazing cattle in rangelands and research the diet formulation itself regarding livestock balance in rangelands for preservation of the rangeland under study.

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TABLE I. CHEMICAL COMPONENT AVERAGE (PERCENT) OF THE STUDIED SPECIES

Plant Samples	Chemical Components							
	DM	Ash	OM	CP	EE	NDF	ADF	WSC
Alhagi	87.64^{b}	7.64^{c}	92.36^{a}	11.07^{b}	2.34^{a}	69.95^{a}	54.19^{a}	3.20^{b}
Psyllium	89.04^{a}	11.31^{a}	88.69^{c}	5.47^{c}	2.14^{ab}	57.80^{c}	39.98^{c}	2.33^{b}
Artemisia	89.31^{a}	8.24^{b}	91.76^{b}	11.46^{a}	2.07^{b}	60.78^{b}	42.50^{b}	8.91^{a}
SEM	0.3350	0.1796	0.1796	0.0196	0.0408	0.3058	0.2190	0.3417

*Averages with similar characters in each column have no significant difference (P<0.05).

*DM: dry matter, Ash: crud ash, OM: organic matter, CP: crud protein, EE: ether essence, NDF: neutral detergent fiber, ADF: acid detergent fiber, WSC: water soluble carbohydrates.

TABLE II. DRY MATTER DEGRADABILITY PARAMETERS FOR EACH STUDIED SPECIE

	Alhagi	Psyllium	Artemisia	SEM
a	13.90b	8.510c	23.26b	0.4131
b	56.22b	58.72a	47.05c	05821
a+b	70.12a	67.23b	70.31a	0.4883
c	0.023b	0.020b	0.062a	0.0018
RSD	2.147b	1.950b	2.85a	0.2995
ED = 0.02	43.83b	38.23c	58.87a	0.2108
ED = 0.05	31.53b	25.57c	49.33a	0.2411
ED = 0.08	26.37b	20.50c	43.83a	0.2337

*In this table: a: soluble particles (fast degradable fraction), b: insoluble particles (slow degradable fraction) which are potentially degradable, c: degradation rate constant (percent per hour), a+b: the whole percentage of food that gets degraded in the rumen (in other words, the potential degradability of food in the rumen), ED: effective degradability (dry matter percentage).

* Numbers with similar characters in each row have no significant difference in statistical terms (P<0.05).

*SEM: standard error of measurement.

TABLE III. PRODUCED GAS (ML IN 200 MG DRY MATTER) AT DIFFERENT HOURS FOR THE STUDIED PLANTS

Incubation Time	Average volume of produced gas (200 mg in ml)			
	Alhagi	Psyllium	Artemisia	SEM
2	4.93[a]	5.36[b]	5.71[b]	0.3045
4	11.29[b]	11.95[b]	13.19[a]	0.4012
6	18.63[b]	17.93[b]	22.33[a]	0.4202
8	24.49[b]	22.01[c]	29.57[a]	0.3931
12	36.27[b]	31.37[c]	39.64[a]	0.3764
24	48.99[b]	43.93[e]	51.77[a]	0.6072
48	56.52[b]	49.69[c]	59.15[a]	0.5861
72	58.60[b]	52.67[c]	62.58[a]	0.7584
96	59.46[b]	54.72[c]	63.78[a]	0.5182
Gas Production Parameters				
b	4.93[b]	5.36[a]	5.71[a]	0.3045
c	11.29[c]	11.95[b]	13.19[a]	0.4012

b: the whole volume of produced gas, c: degradation rate constant
* Numbers with similar characters in each row have no significant difference in statistical terms (P<0.05).

TABLE IV. OMD AND DOMD DEGRADABILITY (G/KG) AND ME (MJ/KG)

Degradability (percentage)	Plant Species			
	Alhagi	Psyllium	Artemisia	SEM
OMD	4.93[b]	5.36[a]	5.71[a]	0.3045
DOMD	11.29[b]	11.95[b]	13.19[a]	0.4012
ME (Mj/k)	18.63[b]	17.93[b]	22.33[a]	0.4202

*OMD: organic matter degradability, DOMD: organic matter degradability in dry matter.
* Numbers with similar characters in each row have no significant difference in statistical terms (P<0.05).